



# RF Signal Switching & Distribution in Civil Aviation Aircraft

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## **Outline**

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- **Rationale/Goals for this Study**
- **Airplanes Physical Description**
- **Important Statistics/Design Concept**
- **Outcome of Design**
- © Conventional Flight Control System
- Fly-by-Wire Flight Control System
- \*\*Airplane's Subsystems and AIMS
- **Onboard Optical Fiber System**
- **RF** Subsystem
- **Summary and Conclusion**
- **Limitations of the Study**



## Rationale/Goals of this Study

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#### **Rationale:**

- OWith emerging technologies (e.g. multimedia, wideband, satellite, GPS), the traditional avionics in civil aviation using coaxial cables or wires may not be adequate
- OInstead of link-by-link communication (using separate subsystems), it is possible to have total system integration providing total system response
- OWith integrated systems significant increase in reliability, capacity, security and safety can be achieved
- OWith advanced technologies, services, previously not available, will be provided to the customers
  - •e.g., wideband communications and interactive multimedia communications within the airplane







## **OTechnology Assessment**

- Evaluate the current status of civil aircraft avionics with emphasis on RF communication subsystem
  - ◆Boeing 777 model aircraft used for this study

### **OTechnology Characterization**

 Characterize the current technology in terms of system performance

### **OMethod of Improvement**

- Determine if system can be improved and if so how?
- Determine areas needing further investigation

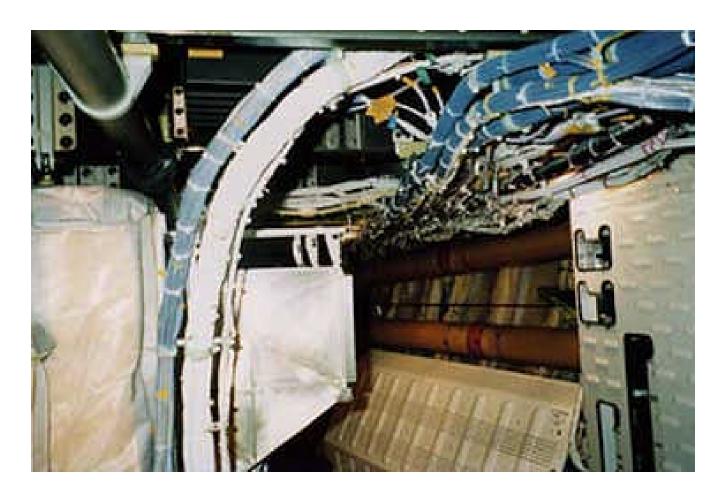


# **Typical Airplane Wiring**



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Wiring in a typical aircraft showing hundreds of meters of cables/wires within the airline cabinet



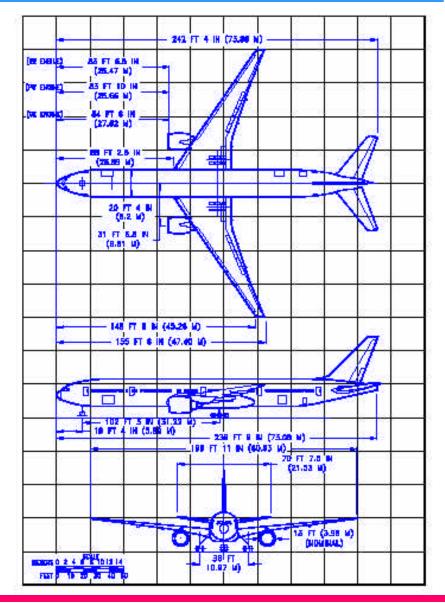
# Airplane's Physical Description



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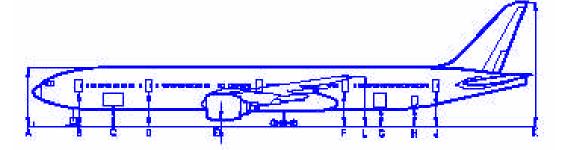
**3-view drawings of**the Boeing 777
aircraft showing
fundamental
dimensions





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# \*\* Lateral view showing ground clearing and fundamental dimensions

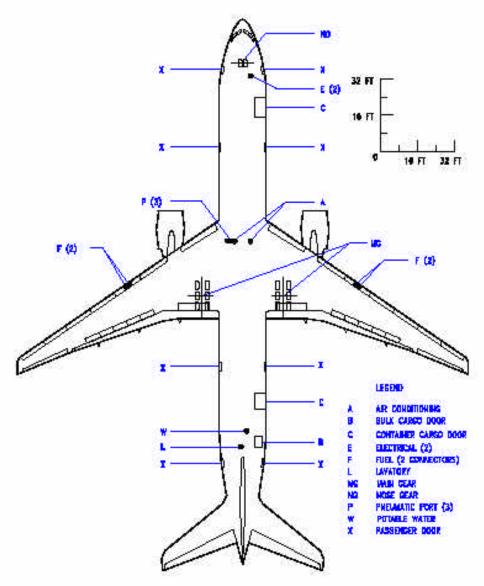


	MRIMUNT		NAXIMUM7	
	FEET - INCHES	METERS	FEET - INCHES	METERS
1.60	27.6	8.39	28 - 6	8.65
В	15-5	4.71	16-5	5.00
ď	9-3	2.81	10 - 0	3.05
D	16.0	4.88	16.7	6.07
E (PW)	3-2	0.96	3-5	1.04
E (GE)	2 - 10	0.85	3-1	0.93
E(RR)	3.7	1.09	3-10	1.17
É	16 - 10	5.14	17 - 4	5.28
D(LARGE DOOR)	10 - 7	3.23	11-2	3.41
G(SMALL DOOR)	10-6	3.22	11-2	3.40
H	10-7	3.23	11-6	3.48
4	17-4	5.28	18 - 2	5,54
Ŕ	60.5	18.42	61-6	18.76
1	23 - 6	7.16	24-6	7.49

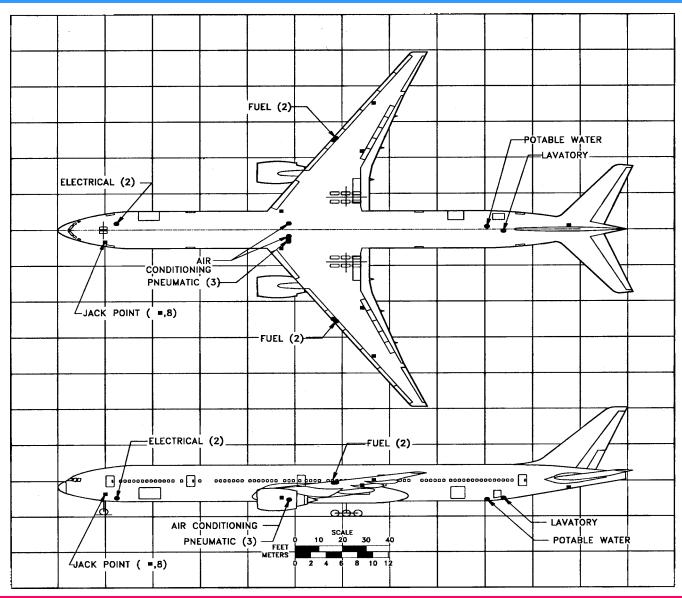


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# Top view showing essential instrument locations









# **Important Statistics/Design Concept**

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#### **Important Statistics**

Estimated cost	\$146 Million	
Size	World's largest twinjet	
Capacity	305-550 passengers	
Engine types	General Electric GE90, Pratt & Whitney PW4000, Rolls-Royce Trent 800	
Range	6,890-8,435 miles	
Parts	132,500 unique parts; 3,000,000 fasteners	

## Innovative Design Approach

O Unlike previous Boeing airplane design using production line mentality, this airline was 100% digitally designed using 3-D solids technology applying CATIA, ELFINI, EPIC design processes





- O 238 teams from diverse groups and 3500 people
  - Teams include Integration, Structures, Systems, Special, Manufacturing
- **™** Network of 2,200 workstations
  - 4 IBM mainframes, linked all over the world
- \*Knowledge Based Engineering
- **Superior Project Management** 
  - O Interdisciplinary team management
  - O Coordination, planning and system integration
  - O Reduce development time from 12 to 5 years

## **Involved Different Agencies**

- O Airline Transport Association
- O Federal Aviation Association
- O Extended-range twin-engine operations approval

## **©** Comprehensive Communication

- O Everyone involved in every step
- O Frequent design reviews, reduced rework by over 75%

## **Answering Customer's Needs**

- OResponds to market needs and customers preferences
- OConfiguration flexibility New advanced cabin management system and excellent cargo capacity
- OMaintained the look and feel of a conventional plane



## **Outcome of Design Concept**

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## **A Superior Aircraft**

- Enhanced reliability and productivity at lower costs
- Most aerodynamically efficiency airfoil wing (climbs quickly, cruises at higher altitudes)
- Most efficient and quickest turbofans
- The More powerful engines with excellent fuel efficiency
- New light weight cost-effective structural material (saves weight, improves corrosion and fatigue resistance)
- © 6-wheel landing gear (other planes have 4-wheel landing gear)
- More economical brake design





- First aircraft to receive certification and 180-minute extended-range twin-engine operations the same day (typically 4 years)
- © Outsold all competing commercial airplanes in its class
- Provides some of the lowest cost per seat mile figures for any commercial transport
- Satellite communication and Global Positioning Systems (GPS)

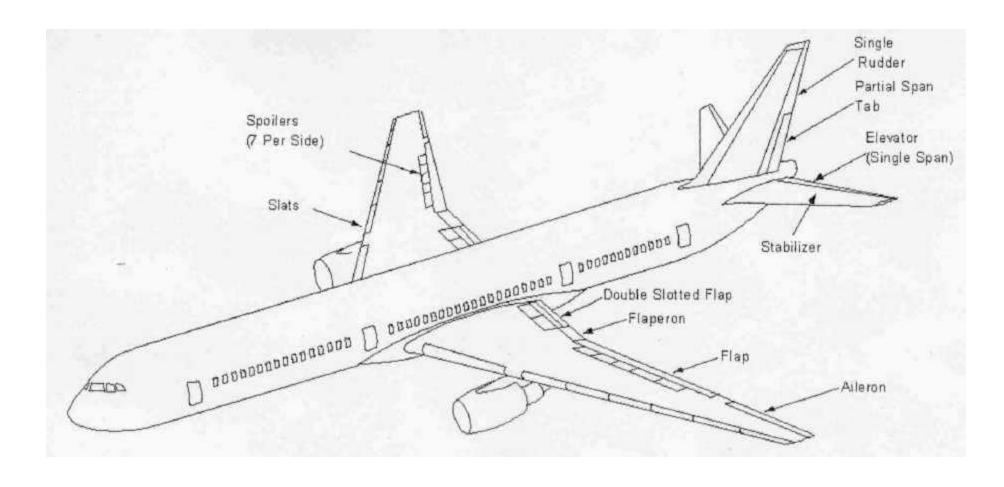
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# **Conventional Flight Control System**



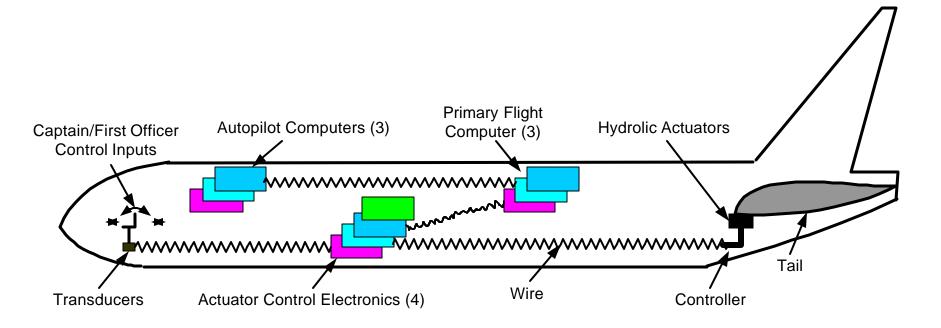
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# Fly-by-Wire Flight Control System

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- Pilot's commands made through the conventional control wheel and rudder pedals are converted to electrical signals
- These signals are then transmitted using computers and electrical wires to the plane's control surfaces





- Pilots have the ability to override the fly-by-wire (FBW) system, giving the pilot the ultimate control of the plane
- Numerous safeguards and backup
  - ONine computers that could run the FBW system alone.
  - OA battery backup on top of a primary backup to run the system should the power to the system be interrupted
  - Original cable system left intact as another backup system
- This design philosophy implies that Boeing has attempted to counter anything that could go wrong

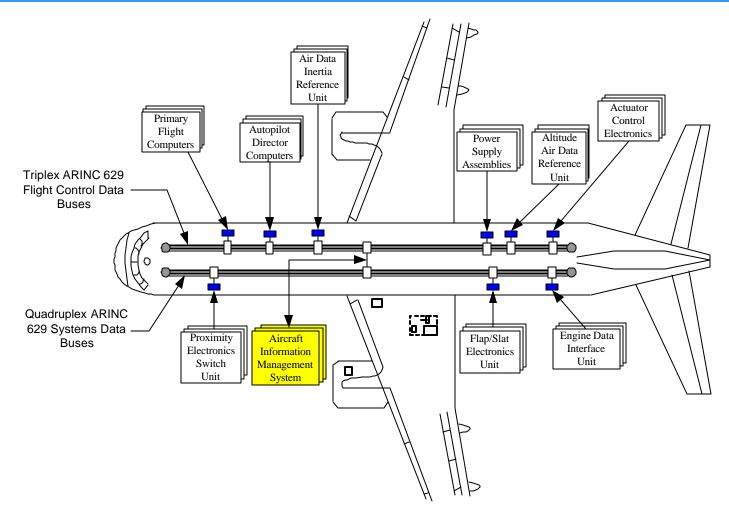


# Airplane's Functional Subsystems



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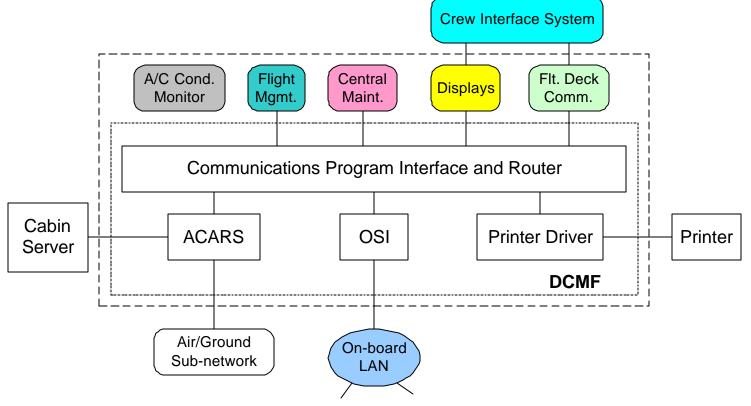
© Different subsystems interconnected via the ARINC 629 data bus



## **AIMS**



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- Airplanes Information Management System (AIMS) is the modular control center
- © Communication functions managed by the AIMS

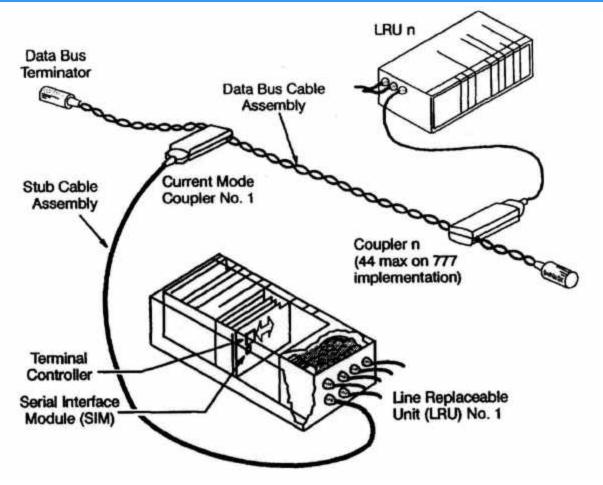


### **ARINC 629 Data Bus**



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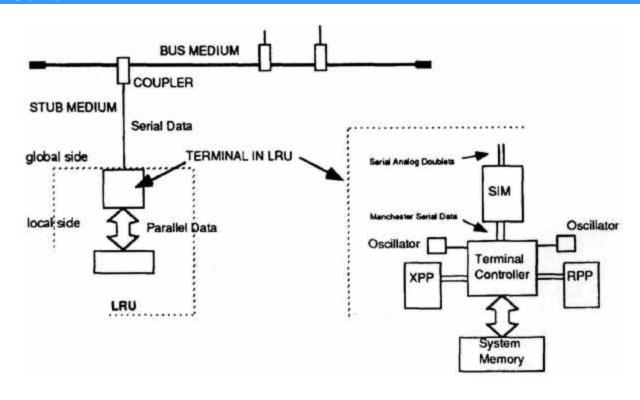
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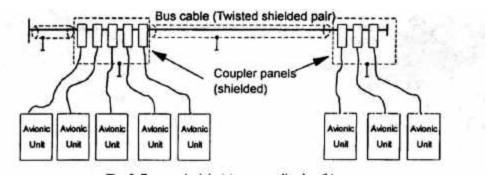


A multitransmitter data
bus - primary
communication
onboard

The data bus is used to achieve the exchange of info between subsystems at high-speed & high-reliability





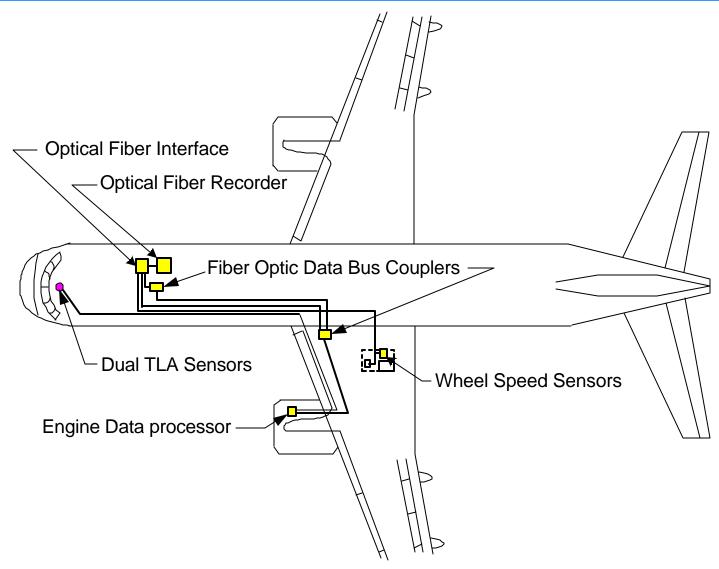




# **Onboard Optical Fiber System**

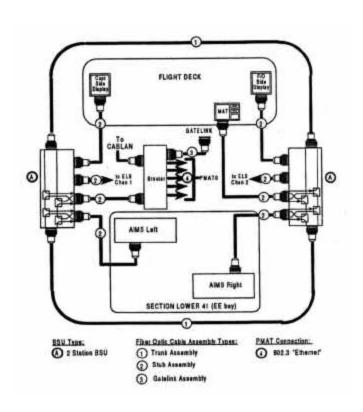


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#### **Avionics Local Area Network LAN**

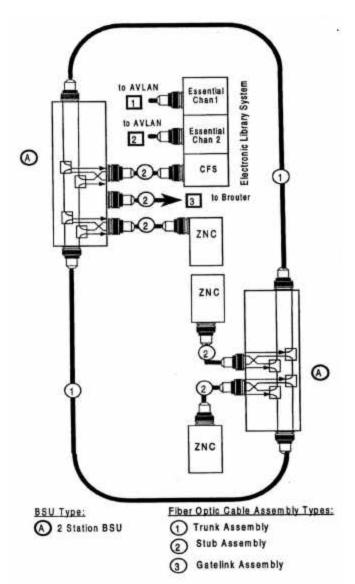


- OAvionics LAN (AvLAN)
  provides high-speed
  communications network
  between various LRU's
- OLAN configuration interfaces the Left & Right AIMS cabinets, the Brouter, and the Maintenance Access Terminal

OAvLAN supports data loading, system functional testing, and aids in fault isolation

#### © Cabin Local Area Network

- OThe main function of CabLAN is passenger entertainment
  - This high speed network
     provides the capability to
     have seat back interactive
     video, various video games,
     and catalog sales
- OCabin LAN interfaces the Zone Network Controllers, Telephone Distribution Units and the Cabin File Server





# **Airplane Wiring**





- © Given this wiring, can the system be improved?
- FIf so, how?
- Is it possible to overlay optical fibers with this wiring system?
- Fly-by-Wire versus Fly-by-Fiber?







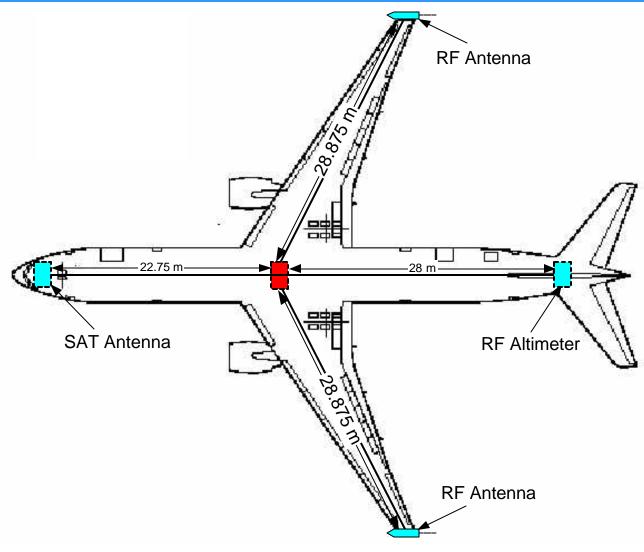
- Without original design blueprint or maintenance manual, it is not possible to isolate any of the subsystem
- **☞ In Boeing 777** 
  - **Odifferent subsystems are integrated**
  - Oisolating a particular subsystem is difficult
  - **Orequires a comprehensive knowledge of the interconnected subsystems**
  - **ORF** subsystem is embedded in the communication and control subsystems



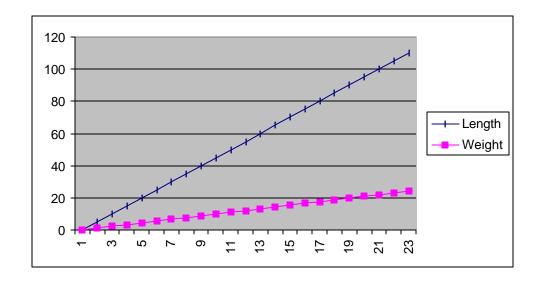
# **RF Subsystem**

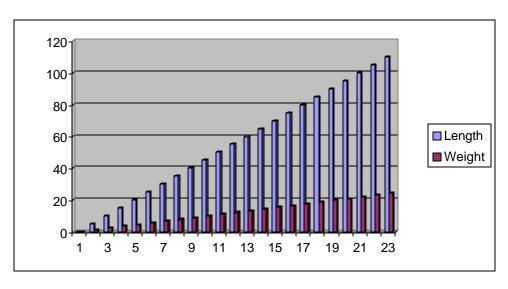


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## **Summary and Conclusion**



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- © Current technology of avionics in a civil aircraft is evaluated
  - OBoeing 777 aircraft was selected for this study
- The design philosophy was discussed
- **Possible methods of improving the current system was investigating**
- We determined that current trend in aircraft aviation is moving towards modular avionics architecture
- Also, it was determined that current trend in aircraft electronics is moving towards FBW control mechanism
- It was more difficult to obtain technical information the any airplane than we taught





- TOptical systems are already being used in aircraft design
  - OBoeing 777 was the first to apply onboard optical local area network
- Tt is not possible to simply overlay optical fibers in existing aircraft communication and control infrastructure due to different design requirement
- \*Hence, the achievable merits of optical fibers cannot be determined quantitatively

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# **Limitations of Study**



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- Difficulty of obtaining original information on any aircraft design was a major drawback
- Tt was very difficult to obtain information from
  - OBoeing Aircraft Manufacturing Company
  - OThe airline industry
  - **O**The Federal Aviation Administration
- Some information obtained from third parties cannot be independently verified
- Description and analysis does not involve actual measurement
  - OUnable to provide measured data
- Tradeoff between optical cables and wires could not be determined